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(58) Field of Search

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(54) Drilling fluid

(57) Water based drilling fluids comprise an aqueous medium, a polyalkylene glycol of formula $R^1O(CH_2 - CH(R) - O)_nH$, wherein R is hydrogen or methyl R^1 is hydrogen or alkyl of 1 - 10 carbons and n is 2 - 200, in amount of 0.5 - 60% by volume of the fluid, and an ester which is at least one of (i) the neutralisation product of an acidic phosphate ester, derived from a fatty alcohol or ethoxylated fatty alcohol, and (ii) a partial ester of a fatty acid, and a polyol with at least 2 hydroxyl groups. The fluid provides a high lubrication with high shale inhibition properties.

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lubricity and shale inhibition.

Although shale is soft and therefore relatively easy to drill through, it still causes many problems for the drilling engineer. It disperses easily into the fluid, large lumps break off and fall into the hole, pores in the shale can contain fluids trapped under pressure, and in extreme cases, the borehole wall may collapse.

Since shale makes up a high proportion of the rocks drilled in exploratory and production wells for oil and gas, particularly in important producing areas such as the North Sea, it is important that drilling times and problems be kept to a minimum when drilling through such formations.

Many WBM formulations incorporating additives have been suggested in an attempt to control reactive shales and enhance the lubricity of the fluid. Such additives include:

(a) salts such as potassium chloride to limit water uptake, reduce the swelling of the shale, and reduce leaching of any salt deposits encountered,

(b) chemically modified starch or cellulosic materials which are used to reduce fluid loss,

(c) water soluble polyacrylamides or other water soluble polymers which adsorb on the surface of shale to bind it with a coating of polymer, thereby reducing dispersion of the shale,

(d) lime or gypsum which although sparingly soluble, act in a similar manner to (a),

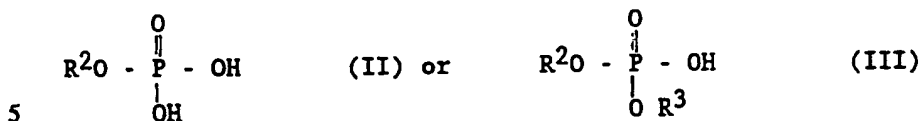
(e) asphaltene derived products such as gilsonite which assist in fluid loss control by acting as blocking agents for cracks and microfractures, and

(f) natural product oils of plant or animal origin to improve the lubricity properties of the fluid.

To date, however, none of these formulations has been able to provide shale inhibition or lubricity to the levels achieved with OBM.

This is because an OBM does not react with shale. A conventional WBM will, however, react to a greater or lesser

formula



wherein each of R^2 and R^3 , which are the same or different, is a radical derived from a fatty alcohol or an ethoxylated fatty alcohol, with an alkali metal hydroxide and (ii) a partial ester of a fatty acid and a polyol with at least 2 hydroxyl groups.

The invention also comprises a mixture of (b) and (c) for use in a water based drilling fluid of the invention.

The polyalkylene glycol or ether (b) is preferably water soluble, e.g. in an amount of at least 10g/l in deionized water at 25°C, and especially is soluble at 25°C in an amount of at least 10g/l in aqueous potassium chloride solution containing 70g/l KCl. The polyalkylene glycol (or ether) may but preferably does not exhibit a cloud point at 3% by weight in distilled water, below 80°C. The glycol or ether usually has an average molecular weight less than 1000 e.g. less than 700 especially 100-600 for polyethylene glycols and 200-450 for polypropylene glycols and 200-550 for copolymeric ethylene/propylene glycols, e.g. with 20-80: 80-20 ethylene oxy to propylene oxy units. The glycol may be tri propylene glycol, but is preferably a homo polyethylene glycol e.g. triethylene glycol, and tetra ethylene glycol, and polyethylene glycol mixtures of the above formula where R^1 and R are H and n is an average of 4-6. Hydroxy ethers with at least one hydroxyl and at least one ether group may also be used, especially monoalkyl ethers (alkyl preferably being of 1-10 carbons, e.g. 1-6 or 1-4 carbons such as methyl, ethyl or butyl) of the above glycols or polyols; examples are the mono butyl ethers of diethylene glycol and triethylene glycol or a polyethylene glycol of the above formula where R^1 is butyl and R is H and n is 2-7, usually with an average of 3. The hydroxy ethers are also preferably derived from homo polyethylene glycols.

usually has a straight aliphatic chain and may be a natural or synthetic acid. Examples of the fatty acid are n-octanoic, decanoic, dodecanoic, lauric, palmitic, stearic, behenic, lignoceric, octadecanoic, and oleic, linoleic, linolenic, ricinoleic and erucic acids. The polyol, which is preferably noncyclic, may be an aliphatic polyol e.g. with 3-10 carbons and 3-7 hydroxyl groups attached preferably to a hydrocarbyl group, such as glycerol, trimethylolethane, trimethylol propane, pentaerythritol, 1,2,4 butane triol and 1,2,6-trihydroxyhexane.

The polyol may also be a ether polyol with 2-7 hydroxyls and 1-10 ether oxygen atoms, such as one of formula I wherein R^1 is H and n is 1-10; examples are di- and tri-ethylene glycol, diglycerol and glycerol bottoms may also be used. The polyol may also be a sugar alcohol, of 5-7 hydroxyls and 5-7 carbons, such as sorbitol, mannitol, or an anhydride thereof e.g. sorbitan.

The esters (ii) are partial esters and have at least one hydroxyl group e.g. 1-5 hydroxyl groups and at least one fatty acid group e.g. 1-3 and especially 1 or 2 such groups. The molar ratio of the number of hydroxyl groups (i.e. non esterified) in the partial ester to fatty acid groups in the partial ester is usually 0.4-6:1, preferably 0.7-5:1 especially 1-3:1. The hydrophilic lipophilic balance HLB value for the partial ester is usually less than 12, such as 1-12, but preferably less than 9 such as 1-6 especially 1.5-4. The partial ester is usually less soluble than the polyalkylene glycol (or ether) in water or in the aqueous KCl solution and may be water soluble in an amount of less than 10g/l e.g. 1-10g/l in deionised water at 25°C and especially soluble in an amount of less than 10g/g e.g. 1-10g/l in aqueous potassium chloride solution containing 70g/l KCl at 25°C.

The amount of the phosphate ester in the water based drilling fluid of the invention is usually 0.05-5% by volume e.g. 0.1-1% by volume and the relative volume of the polyalkylene glycol (or ether) (b) to phosphate ester c(i) is usually 1:1-20:1 e.g. 5:1-15:1. The amount of the carboxylic ester c(ii) in the water based drilling fluid of the invention is usually 0.1-10% by

Example 1Preparation of Combined Lubricant/Shale Inhibitor Package
Neutralising Solution

To 200g of a mixture of polyethylene glycols with an average
5 molecular weight of 194 and an average of 3-5 ethylene oxy groups,
30g of crushed potassium hydroxide was slowly added while stirring
vigorously and maintaining the temperature at 150°F (66°C). The
resulting solution was allowed to cool.

Preparation of Package A

10 To 100g of a mixture A of polyalkylene glycols which are
copolymers of ethylene oxide and propylene oxide in molar
proportion of 1:1 and average molecular weight of 500 which has a
cloud point in distilled water at less than 80°C, was added 10g of
a phosphated ester of polyoxyethylene (3) oleyl alcohol. With
15 vigorous stirring of this resulting mixture, 12g of the
neutralising solution was added until a pH of 7 was obtained to
afford a sample of Package A.

Preparation of Package B

The preparation was similar to the preparation of Package A
20 but used, instead of mixture A, a mixture B which was mono butyl
ethers of a mixture of polyethylene glycols with 2-7 ethylenoxy
groups and an average of 3, and an average molecular weight of
230. This ether mixture B was soluble at 25°C, both in water and
in aqueous KCl solution containing 70g/lKCl in amounts greater
25 than 10g/l. The ether mixture does not exhibit a cloud point at
3% by weight in distilled water below 80°C.

For maximum efficiency, Package A or Package B should be
added to whole mud systems at a level of 3% by volume.

Laboratory Evaluation of Lubricity and Shale Inhibition

30 The performances of Packages A and B were evaluated in
seawater in the presence of potassium chloride, potassium formate
and potassium acetate (and for the lubricity experiments, also in
the presence of xanthum gum to confer viscosity). Seawater and
potassium chloride form the typical 'base' fluid of a water based
35 mud system; however, alternative sources of potassium ions such as

SW/KFormate/Package B 98

0.06

SW = seawater

- 5 * All potassium salts added at 10ppb.
 * Mixture A and B additives added at 8.8 ppb (2.5% wt/wt)
 * Package A and Package B additives added at 10.5 ppb (3% wt/wt)
 * Lubricity measurements - fluid comprises seawater, 1 ppb xanthan
 gum polymer to confer viscosity and additives at above
 10 concentrations.

Conclusion: The copresence of the mixture A or B with the
 phosphate ester enhances both the lubricity of the fluid and its
 shale inhibition properties.

Example 2

15 Procedure

To assess highly inhibitive fully formulated water based
 drilling fluid ("mud") systems, a more aggressive cuttings
 dispersion test was adopted. The test used approximately 100
 grams of London Clay or other suitable shale chips in the size
 20 range 4-8mm. The chips were placed inside a cylindrical drum
 whose curved surface comprised a 5mm brass or steel mesh. The
 drum containing the shale was partly immersed (to half the
 diameter of the drum) in the mud under test and the drum rotated
 for 4 hours. After this time the shale remaining was recovered,
 25 washed, dried and the amount of shale lost by dispersion into the
 fluid calculated. Examinations of the amounts of shale recovered
 in differing mud systems provide comparisons of the relative
 inhibitive nature of the mud systems under test.

	<u>Mud System</u>	1 Seawater
30		2 KCl - 25 ppb
		3 Xanthan gum - 1 ppb
		4 Drilling starch - 4 ppb
		5 Anionic polyacrylamide - 1 ppb

The components were added in the above numerical sequence
 35 with stirring on a Hamilton Beach mixer at high speed for 5

Base + Package B 25 26 11/14 7.3
(After Hot Rolling)

Base 23 26 10/12 8

Base + Package A 22 24 11/12 7

5 Base + Package B 25 22 10/13 7.5

Units: PV (Plastic Viscosity, cP); YP (Yield Point lb/100ft²); Gel (10s/10m), Fluid Loss (ml)

Conclusion: The presence of Packages A and B does not affect rheological mud properties.

10 Example 4

To 150g of the mixture B ethers used in Example 1 was added 50 g of a commercial partial ester of a fatty acid, as further described below. Solutions with one liquid phase at 25°C were formed and were stirred for 30 min. The partial esters were (X) glyceryl monooleate HLB 3.3 (sold as GMON/E by Croda), (Y) tetraethylene glycol monooleate), and (Z) glyceryl monoricinoleate HLB 3.6 (sold as GMR S/E by Croda) to give with the mixture B ethers as described above solutions designated packages X, Y and Z respectively.

20 The packages X and Y were tested for their activity in lubricity and shale inhibition in the same way as were tested packages A and B in Example 1.

The Results were as follows:

	FLUID COMPOSITION	% SHALE RECOVERY	LUBRICITY CO-EFFICIENT
25	SW	1	0.32
	SW/KCl	6	0.32
	SW/KCl/Mixture B	88	0.23
	SW/KCl/Package X	100	0.04
	SW/KCl/Package Y	98	0.11
30	SW/KCl/Package Z	100	0.04

Example 5

The process of Example 2 was repeated with the mud system of Example 2 and then addition of components as specified below.

35 Results:

(0.6ppb), xanthan gum (1ppb), drilling starch (2ppb), anionic polyacrylamide (1ppb) and baryte (187ppb) and variable amounts of Package X. The mud was not heat treated prior to use.

The water based mud systems were then tested for lubricity in apparatus representing a 1/4 scale simulation of the contact between a drillstring and pipe casing or formation core. The mud was evaluated under flow conditions (ca. 5 l/min) in a circulating system at 60°C. Package X was added to the mud at 1.5%, 3.0%, 4.5% and 6.0% (weight) in 10 minute intervals via shear mixing into the mud reservoir.

PIPE CASING: An N80 carbon manganese steel cylinder was used for the pipe casing specimen - 65mm long, 101.4mm in outer diameter and 50mm in internal diameter.

DRILL STRING: The drill string specimen was made of EN19T steel (0.4% C, 0.35% Mo, 1.0% Cr, 0.05% S). It was 40mm long and 31.5mm in diameter.

SIDE LOAD: A 150 N side load was applied during the testing. Under the geometry of the apparatus this represented a typical side load of 260 lb/ft at a rotation speed of 400rpm (corresponds to 100rpm for full size drill pipe).

RESULTS:

Friction between pipe casing and drill string

	Amount of Package X	Reduction in friction
	(% by wt)	coefficient (%)
25	1.5	11
	3.0	32

There was no further reduction beyond 32% in the friction coefficient in drilling muds with 4.5% or 6.0% by weight of Package X.

30 Examples 8-11

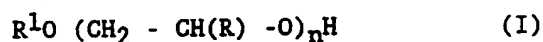
Lubricity tests were performed on a number of drilling mud formulations made from sea water (200ml), xanthan gum (1ppb) and potassium hydroxide to pH10, then the ester as described below (1.5g) and finally the butyl glycol ether mixture used in Package B (4.5g). The test was performed as described in Example 1, but

Claims:

1. A water based drilling fluid comprising:

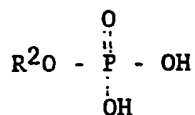
(a) an aqueous medium,

(b) a polyalkylene glycol (or ether) of general formula:

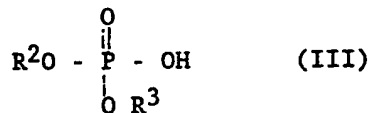


5 wherein R is H or CH₃, R¹ is H or an alkyl group containing 1 to 10 carbon atoms and n is a number in the range 2 to 200 in amount 0.5 to 60% by volume of the fluid, and

(c) an ester, which is at least one of (i) the
neutralisation product of an acidic phosphate ester of general
10 formula



(II) or



15

wherein each of R² and R³, which are the same or different, is a radical derived from a fatty alcohol or an ethoxylated fatty alcohol, with an alkali metal hydroxide and (ii) a partial ester of a fatty acid and a polyol with at least 2 hydroxyl groups.

20 2. A fluid according to claim 1 which is one liquid phase at 25°C.

3. A fluid according to claim 1 or 2 wherein the glycol or ether (b) is water soluble and has an average molecular weight of less than 700.

25 4. A fluid according to claim 3 wherein the glycol or ether (b)

Patents Act 1977
Examiner's report to the Comptroller under Section 17
(The Search report)

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Relevant Technical Fields

(i) UK Cl (Ed.M) E1F FGP

(ii) Int Cl (Ed.5) C09K

Search Examiner
 MR D B PEPPER

Date of completion of Search
 20 DECEMBER 1994

Databases (see below)

(i) UK Patent Office collections of GB, EP, WO and US patent specifications.

(ii) ONLINE WORLD PATENTS INDEX

Documents considered relevant following a search in respect of Claims :-
 1 TO 10

Categories of documents

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| <p>X: Document indicating lack of novelty or of inventive step.</p> <p>Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.</p> <p>A: Document indicating technological background and/or state of the art.</p> | <p>P: Document published on or after the declared priority date but before the filing date of the present application.</p> <p>E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.</p> <p>&: Member of the same patent family; corresponding document.</p> |
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Category	Identity of document and relevant passages	Relevant to claim(s)
A	EP 0495579 A (B.P)	1, 8 & 9

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